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Relationship between Growth Factors and Spectral Characteristics of Satellite Imagery in Korea

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ABSTRACT : This study attempts to analyze the relationship between forest volume and age based on 5th NFI data and spectral characteristics of satellite imagery using ASTER sensor in Korea. Forest stand volume and age had the negative correlation with the spectral reflectance in all of the band (Blue, Green, Red, SWIR). With increasing of stand volume and age, spectral reflectance decrease. The spectral reflectance of band1 showed the highest correlation between stand volume and spectral reflectance among the VNIR wavelength. The spectral reflectance band 1, 2 (visible wavelength) and stand age have high correlation compared to other bands. The correlation coefficients between forest volume and vegetation indices have low relationship. This result indicates that the reflectance of blue band may be important factor to improve the potential of optical remote sensing data to estimate forest volume and age.

Keywords : NFI, ASTER, Spectral reflectance, Forest volume

INTRODUCTION

Many studies have investigated the relationship between forest volume and satellite spectral reflectance. SPOT and Landsat data have a primarily negative correlation with forest volume (Trotter et al., 1997), the correlation between spectral data and wood volume tends to be stronger for younger stands than older stands (Peterson and Nilson, 1993). And forest inventories and remote sensing are the non-linear regression analysis used for estimating biomass (Muukkonen and Heiskanen, 2005). A common approach is the combination of satellite image data and field data assessed from sample plots for estimating forest variables for each pixel of the image. After the estimation at the pixel level, estimates for forest stands can be calculated as an average of pixel estimates with a stand (Katila and Tomppo, 2001). Thus various remote sensing studies concerning forest volume estimation have used plot measurements as field data.

The objective of the present study was to estimate the relationship between the spectral reflectance recorded ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) satellite sensor and the forest volume of field data from the National Forestry Cooperative Federation in Gangwon-do.

MATERIALS AND METHODS

Study area

The study area of Gangwon-do in Korea peninsula were selected this study. Most of the land in Gangwon-do

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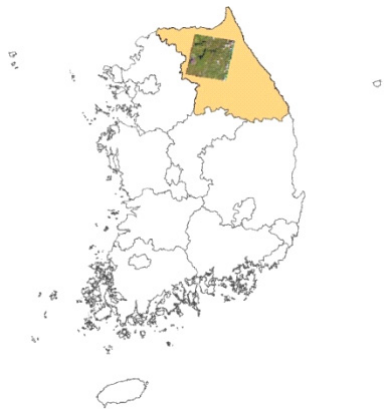

Fig. 1. Location of the study area.

consists of mountainous area. This area has an elevation range from 100 to 500 m (46%) and 500 to 1,000 m (43.4%), which is the highest rate in Korea, while high mountainous regions over 1,000 m represent 5%. And the main tree species in Gangwon-do are *Pinus densiflora* and *Quercus mongolica*.

NFI (National Forest Inventory) data

The NFI of Korea begun in 1972 with 10 year intervals. The new 5th NFI begun in 2006, and it will be fully completed in 2010. NFI data was measured about 800 samples every year within 5 years. The measured variables were forest type, GPS position, canopy closure, tree species, dbh, height, 5 year growth, crown class, quality, bark thickness, soil type, vegetation, stump, deadwood, litter, etc.

Field data were used to estimate relationships between the measured forest parameters and the satellite image data. The field data were taken from the NFI that is an annual forest inventory in 2006 and 2007. The plots were 16 m in radius and located on sub-plots (11.3 m) that varied in the direction 0°, 120°, 240° length from 50 m. Forest stand volume was estimate measured in 54 plots (24 plots in 2006 and 30 plots in 2007) of the sample plots elevation above sea level 85~1,060 m in the study. The forest types are deciduous (27), coniferous (9), mixed (18), the stand age is 20~83, the stand volume is 43.5~275.77 m^3/ha. The average stand volume of 4 sub-plots was used.

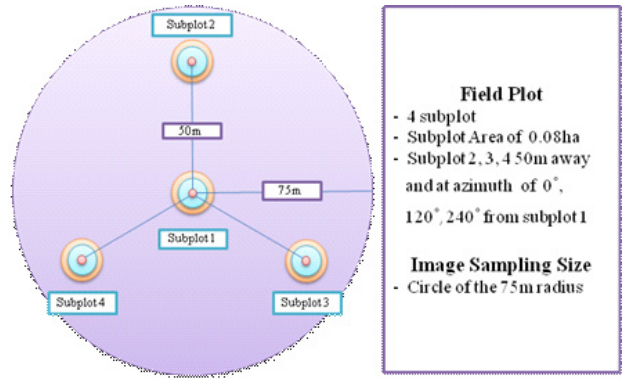

Fig. 2. Sample plot design.

Table 1. Field data description(NFI)

	Min	Max	Avg
Stand Age (year)	20	83	40
Stand Volume (m^3/ha)	43.50	275.77	149.64

Remote sensing data

For the study, we obtained ASTER sensor data acquired on September 5, 2005. The ASTER (Advanced Space-borne Thermal Emission and Reflection Radiometer) is an imaging instrument flying on Terra, a satellite as part NASA's Earth Observing System (EOS). ASTER is a high resolution multispectral image with three subsystem operating in different spectral region, namely the visible and near infrared (VNIR), the shortwave infrared (SWIR), and the thermal infrared (TIR). In order to extraction the

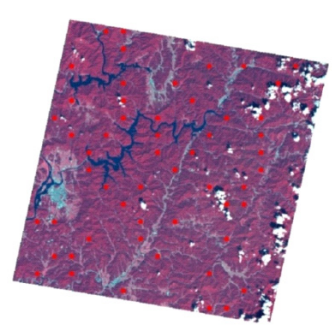

Fig. 3. ASTER image and sample plot.

spectral reflectance of satellite image, we use the feature extractions from the plots with a radius 75 m.

Pre-processing

ASTER images were geo-referenced to the local plane rectangular coordinates by using a set of ground control points obtained from the 1:25,000 scale digital topographic maps. It was radiometically calibrated, and converted to surface reflectance value. Digital Number (DN) value was converted to the sensor-received radiance by applying gain and offset coefficients, the radiance value was transformed to percent reflectance after the atmospheric correction (Lee et al., 2004). We used MODTRAN radiative transfer code to calculate the atmospheric transmittance and other terms using a standard atmospheric model and local meteorological data for the atmospheric correction.

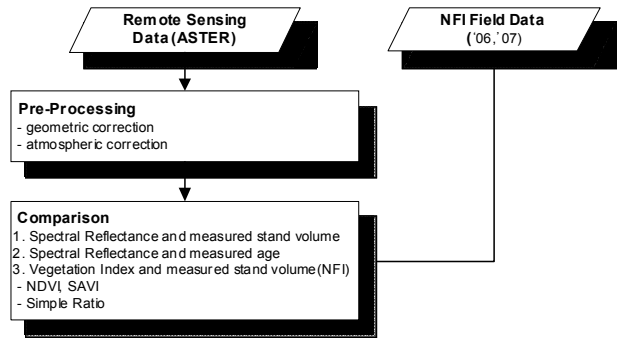

Fig. 4. Flow chart of the pre-processing.

Table 2. Correlation coefficients of forest stand variables versus spectral reflectance.

	Band								
	Blue (1)	Red (2)	NIR (3)	SWIR					
				4	5	6	7	8	9
Volume (m^3/ha)	-0.24	-0.17	-0.04	-0.11	-0.27	-0.20	-0.25	-0.22	-0.17
Age (years)	-0.41	-0.42	-0.13	-0.11	-0.14	-0.16	-0.12	-0.10	0.00

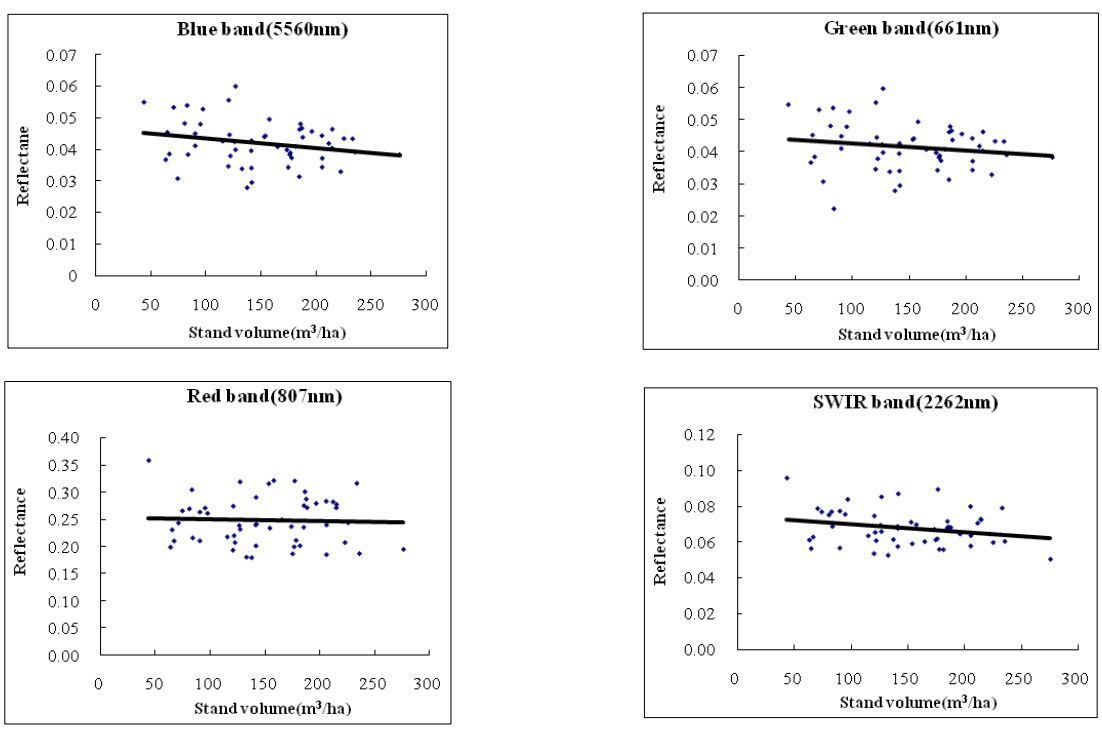

Fig. 5. Relationship between the field measured stand volume and spectral reflectance.

RESULTS AND DISCUSSIONS

Forest stand volume and age had the negative correlation with the spectral reflectance in all of the band (Blue, Green, Red, SWIR). The spectral reflectance of band1 showed the highest correlation between stand volume and spectral reflectance among the VNIR wavelength. Band 3 (NIR) has lowest correlation. The spectral reflectance band 1, and 2 (visible wavelength) and stand age had high correlation compared to other bands. The correlation coefficient between forest age and spectral reflectance had the negative relation. The extracted VNIR and SWIR reflectance showed the rate of decline against the forest age.

The vegetation indices have been widely used in various applications. It responds to change in amount of biomass, chlorophyll content, and water stress. It is simple and easy to implement method when forest canopy closure is not too sparse or dense.

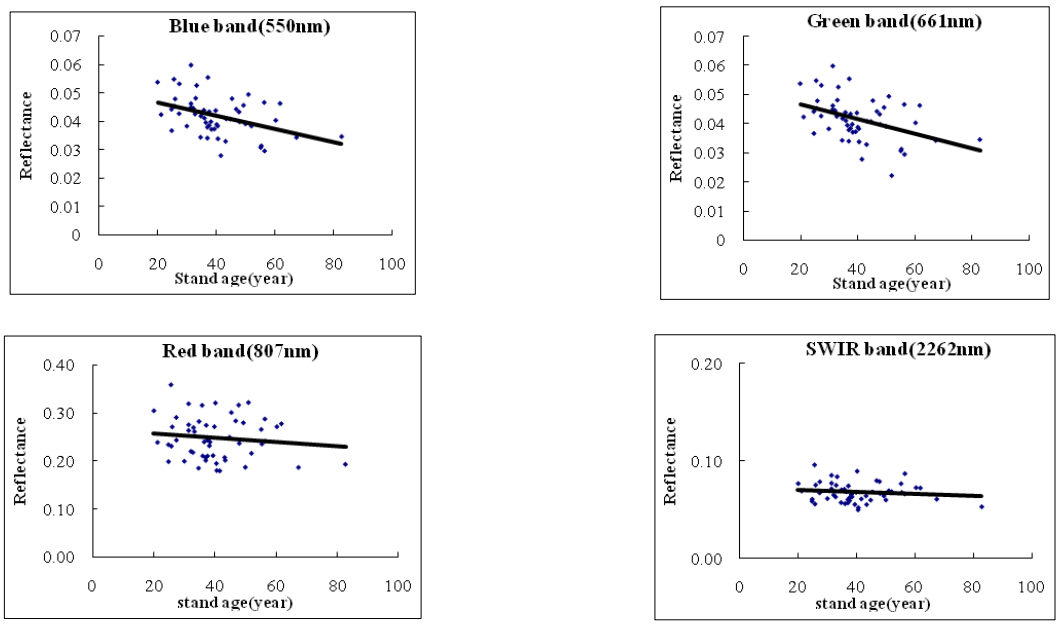

Fig. 6. Relationship between the field measured stand age and spectral reflectance.

Table 3. Correlation Coefficients of forest stand variables versus Vegetation Index

	Vegetation Index		
	SR	NDVI	SAVI
Volume (m^3/ha)	0.05	0.11	0.01

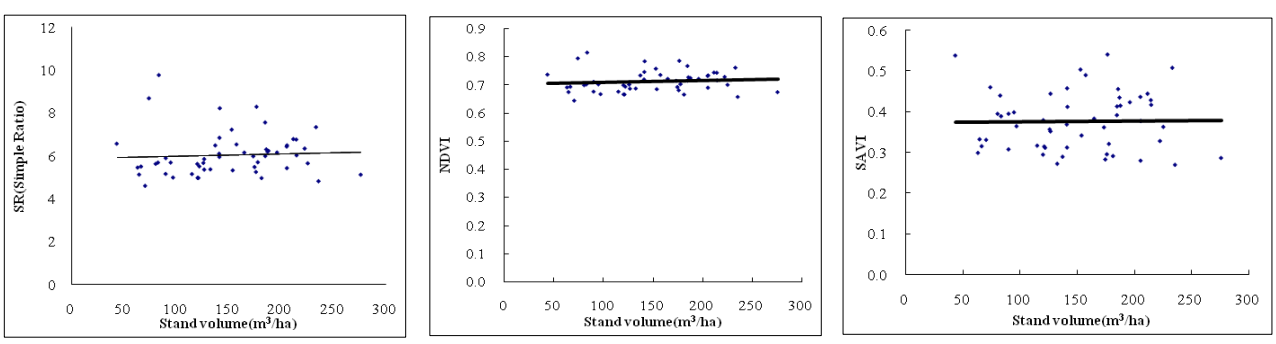

Fig 7. Relationship between the field measured stand volume and SR, NDVI, SAVI.

The soil-adjusted vegetation index (SAVI) is eliminating the background soil effects. And slop of the soil line is determined the 1.49.

Among the vegetation indices, the correlation coefficient between NDVI and stand volume has the highest relationship.

$$\text{SR(Simple Ratio)} = \frac{\text{NIR band}}{\text{Red band}}$$

$$\text{NDVI} = \frac{\text{NIR} - \text{Red}}{\text{NIR} + \text{Red}}$$

$$\text{SAVI} = \frac{(\text{NIR} - \text{Red})(1 + \text{L})}{(\text{NIR} + \text{Red} + \text{L})}$$

$$\text{L} = 1 - 2\alpha\text{NDVI} \times \text{WDVI} \quad (\alpha = 1.6)$$

$$\text{WDVI} = \text{Red} - \gamma\text{Red} \quad (\gamma = \text{slop of the soil line} = 1.49)$$

CONCLUSIONS

In this study, the forest volume and age have the negative correlation coefficients comparing the spectral reflectance. The spectral reflectance has low value according to the increment of stand volume and age. The reflectance of band 1 (Blue) and SWIR has higher relationship than other wavelength to determine the forest stand. In the forest stand age, the band 1, 2 (Blue, Red) have high relationship as compared with NIR and SWIR wavelength. The Vegetation Indices have low relationship.

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